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Investigating precipitation extremes over West Africa using two regional climate models from 1981 to 2010

Ibrahima Diba[1], Didi S. Regis[2-3-4], Salomon Obahoundje[2-4], and Moctar Camara[1]

[1]Département de Physique, Laboratoire d'Océanographie, des Sciences de l'Environnement et du Climat (LOSEC), Université Assane SECK de Ziguinchor, Senegal

[2]African Centre of Excellence on Climate Change, Biodiversity and Sustainable Development, Université Félix Houphouët Boigny, Abidjan, Côte d'Ivoire

[3]Université Nangui Abrogoua, UFR Sciences et Gestion de l'Environnement, Abidjan, Côte d'Ivoire

[4]Laboratoire Mixte International LMI-NEXUS, Université Félix Houphouet-Boigny, Abidjan, Côte d'Ivoire

ABSTRACT: This study aims to analyze and compare the performance of two regional climate models (RegCM4.5 and WRF3.5) in simulating extreme rainfall over West Africa. We performed two simulations respectively at a spatial resolution of 50 km with the RegCM4.5 model at a spatial resolution of 12 km with the WRF3.5 model. These runs cover the period 1981-2010 and the driving fields (lateral boundary conditions) are from the Era-Interim reanalysis. The RegCM4.5 model simulates dry (wet) biases over the Sahel (Guinea Coast) while the WRF3.5 model simulates an opposite bias. This could be explained partly by the fact that the RegCM4.5 (WRF3.5) model underestimates (overestimates) the relative humidity and the monsoon flow over the Guinea Coast compared to the ERA-Interim reanalysis. Results also show that the spatial distribution and the annual cycle of rainfall over West Africa are well simulated by the two regional climate models despite the presence of some biases. The number of rainy days decreases from the southern to the northern Sahel for CHIRPS data and both regional climate models. All datasets show the highest rainfall intensities and the strongest values of the intense rainfall events over the Fouta Jallon highlands, Jos Plateau and Cameroun Mountains. The maxima of the mean 95th percentile of daily rainfall is located over the Guinea zone for CHIRPS datasets and both regional climate models. All datasets show a spatial distribution of the consecutive wet days similar to the number of rainy days with strong values over the orographic regions. When considering the consecutive dry days, all datasets exhibit strong values of this parameter north of 17.5°N (northern Sahel). The shorter consecutive dry days are observed over the area of the maximum precipitation (over the southern Sahel and the orographic regions). In terms of model biases, this study shows substantial differences between the two regional climate models used in this study suggesting the necessity to perform models intercomparison during the present-day before any choice for future projections.

KEYWORDS: Regcm4, WRF, Extreme rainfall, West Africa.

1 INTRODUCTION

Climate change is affecting many climate variables, including rainfall. In addition, few studies have been devoted to daily extreme rainfall events over West Africa due to several difficulties, such as the availability and access to daily weather data [1], [2]. For this reason, regional climate simulations have received much attention in recent years. For more than three decades, regional climate models (RCMs) have emerged as a transitional tool to provide detailed estimates of weather parameters (temperature, precipitation, humidity, wind, etc.) for regional applications. Their dynamic downscaling approach was intended to bridge the gap between the global but coarse estimates of global climate/circulation models (GCMs), which typically had a resolution of 2.5°, and practical requirements such as precipitation estimation for hydrological operations under small increases in greenhouse gas emissions. Over the three decades, RCMs have provided data to inform policy and have contributed to a better understanding of the current climate and the effects of global warming at the regional level, thanks to advances in computational power and exploitation of parallelism in numerical codes that now allow simulations to be run at finer resolutions as well as projections to 2100 [3]. These RCMs can bring significant added value to global reanalysis and GCMs and in particular lead to a better representation of the West African monsoon.

The GMCs models do not solve the sub-grid processes, which cannot be computed explicitly or solved on the model grid. In current global models, parameterization is necessary for convection, cloud cover, energy transfer (radiative or latent heat), or surface, continental or hydrological processes. The phenomena under mesh are a source of uncertainties. The parameterization of the cloud cover is the main source of bias in the models according to [4]. It should be noted that these shortcomings often stem from a lack of observation and understanding of the processes involved. The choice of parameterizations of the models, and physical schemes, are critical elements and one of the causes of the divergence of outputs from different models. This aspect has been shown with regional models, notably by [5]. In West Africa, where rainfall is limited to only a few months per year except for the coastal regions, a correct representation of the West African monsoon circulation and the associated onset and cessation of the rainy season are of utmost interest for farming management [6]. In recent studies [7], [8] showed that the ability of RCMs in simulating onset and cessation of the rainy season over West Africa strongly depends on how well the models reproduce the northward movement of the monsoon system and its associated features. Since RCMs are nested in a global solution, this tie to large-scale features can pose challenges for regional climate modeling studies [9]. Uncertainties also arise from the sparse observational network and the considerable differences in the derived gridded observation products for the region, against which models are validated and calibrated [10].

In this context, the Coordinated Regional Climate Downscaling EXperiment (CORDEX) project [11] sponsored by the World Climate Research Programme (WCRP) has equipped the African continent with several climate data from RCMs forced by GCMs of the Coupled Model Intercomparison Project Phase 5 (CMIP5) that serve as scientific support to the Intergovernmental Panel on Climate Change (IPCC) reports. Among these, two types of dynamically downscaled models such as Weather Research Forecast version 3.5 (WRF3.5) and RegCM version 4.5 (RegCM4.5) that have been used in several studies in the West Africa region have attracted our attention.

Regarding the use of the RegCM4.5 model over West Africa, several works have been recorded. Solmon et al. (2012) [12] studied the effect of dust on climate over West Africa using the RegCM model. Browne and Sylla, (2012) [13] performed a model sensitivity study as a function of simulation domain over West Africa and showed that a large domain is needed to capture the variability in rainfall characteristics and summer monsoon circulation using the RegCM model. Adeniyi (2014) [14] indicated that all RegCM model convective schemes give a good spatial representation of rainfall over West Africa. The RegCM4.5 model has recently been used for a study of monsoon characteristics over West Africa during warm years [15] and attempts to investigate a sensitivity study using different convective schemes to identify the best model configuration option [16]. Previous studies on rainfall variations in West Africa indicate a delayed and, in some cases, shortened monsoon season, characterized by a late-onset and early withdrawal [17], [18], [19]. On the one hand, likely, such a change in the West African monsoon cycle will also impact the occurrence of precipitation extremes at seasonal and or sub-seasonal scales as shown by [20] and on the other hand, the timing of the onset of extremes included in the monsoon changes. Therefore, it is important to evaluate the seasonal structure of changes in extremes concerning the RegCM4.5 model in the evolution of the monsoon cycle.

Concerning the use of the WRF model over West Africa, several works have also been recorded and particularly in the prediction and monitoring of regional extreme weather and climate events (cyclones, high winds, storms, etc.) and air quality. The first studies were carried out by [21] using the medium-scale meteorological model MM5 first implemented by [22] at 9 km resolution over two different periods (1991-2000 and 2030-2039) over a relatively small area covering the Volta basin. After the evolution from MM5 to WRF, the new version performance was evaluated by testing the dynamics of the West African monsoon at the beginning of the rainy season for the year 2006 [23] and examining its sensitivity to horizontal resolution and physical patterns in the replication of precipitation over West Africa for the year 2014 [24]. Currently, it is the subject of a large-scale program coordinated by the West African Science Service Center on Climate Change and Adapted Land Use, abbreviated as WASCAL, focused on research designed to help address the challenge of climate change and thus build resilience in human and environmental systems. Funded by the German Federal Ministry of Education and Research, WASCAL's research activities in Africa are coordinated by its competence center in Ouagadougou, the capital of Burkina Faso, under the leadership of the Center for Development Research at the University of Bonn in Germany. An integral part of the WASCAL Program's core research is the provision of a new set of high-resolution regional climate projections for West Africa [25].

In the context of our study, falling under the problematic "extreme weather and climate phenomena", these two models seemed very useful since they allow us to go down to fine scales.

The objective of this work is to analyze and compare the performance of two regional climate models (RegCM4.5 and WRF3.5) in the representation of extreme precipitation, relative humidity, and winds at different levels over West Africa for the current climate.

This study is structured as follows. In Section 2, the model description, the data and methods, and the definition and types of climate extremes used are presented. Section 3 presents and discusses results followed by the conclusion in Section 4.

2 Models Description, Data And Methods

2.1 Regional Climat Model (RegCM4) Model

We used the fourth generation of the Abdu Salam International Centre for Theoretical Physics (ICTP) regional climate model released version 4.5 (RegCM4.5). This model is extensively described by [26]. Briefly, the RegCM4.5 is a hydrostatic, compressible, sigma-p vertical coordinate model which includes various options of physics parameterizations. All details about the model configuration (the radiative transfer calculations, the land surface scheme, the planetary boundary layer scheme, the large scale precipitation processes scheme) and the experimental design are extensively described in [27]. The simulation domain, as well as the considered sub-domains (Western Sahel, Central Sahel, Eastern Sahel, and the Guinea region), are represented in Figure 1. The domain was enough large to properly minimize inconsistencies between boundary conditions and the model. The model has been integrated from November 1980 to December 2010.

2.2 Weather Research Forecasting (Wrf) Model

The work presented here advances the regional downscaling efforts for the region through the generation of a high-resolution, ensemble regional climate simulation experiment for large areas of continental West Africa and extensive periods of the 21st century at a horizontal resolution of 12 km. Three GCMs are downscaled using the Weather Research and Forecasting Model [28] to narrow down uncertainties and provide estimates on the range of climate change impact on the region. This contribution presents the overall concept of the WASCAL regional climate simulations, as well as detailed information on the experimental design, and provides information on the format and dissemination of the available data. All data are made available to the public at the CERA long-term archive of the German Climate Computing Center (DKRZ) with a subset available at the PANGAEA Data Publisher for Earth & Environmental Science portal (https://doi.pangaea.de/10.1594/PANGAEA.880512).

2.3 Chirps Data

Rainfall data from the CHIRPS (Climate Hazards Group Infrared Precipitation with Stations [29] version 2.0) produced by the Climate Hazards Group at the University of California was used to validate the two regional climate models and to investigate the changes in precipitation during the period 1981–2010. CHIRPS is a quasi-global rainfall dataset spanning between 50°S-50°N and starting from 1981 to the present. CHIRPS incorporates 0.05° spatial resolution satellite imagery with in-situ station data to create gridded rainfall time series suitable for trend analysis and seasonal drought monitoring. CHIRPS data is available at 5 and 10-day accumulations. CHIRPS are freely available at: http://chg.geog.ucsb.edu/data/chirps/. CHIRPS dataset was validated at the river basin level in West Africa [30]. This product was also shown to be strongly correlated to in-situ observations in major climatic zones of the West Africa region [31].

2.4 Era-Interim Reanalysis

In the last part of this analysis, we used relative humidity and wind data from Era-Interim reanalysis [32], [33] to explain the changes obtained in mean and rainfall extremes. The ERA-Interim reanalysis analyzed here has a spatial resolution of 0.125° x 0.125°. These reanalysis are global data sets produced by the European Center for Medium-Range Weather Forecasts (ECMWF, [34]) and cover the period from 1st January 1979 to 31st August 2019. They are mesh data available at different spatial resolutions and on 37 pressure levels. The reanalysis data are currently the best way to describe the state of the atmosphere and are extensively used previously over West Africa to validate climate models [12], [18], [20].

2.5 Methods

We used seven (7) hydro-climatic indices recommended by the World Meteorological Organization [35] Expert Team on Climate Change Detection and Indices summarized in Table 1 [36]. These indices are previously used for several studies over West Africa [27], [31], [37], [38]. Detailed descriptions of the indices and the exact formula for calculating them are available on the Expert Team on Climate Change Detection monitoring and Indices (ETCCDI) web page (http://etccdi.pacificclimate.org/list_27_indices.shtml)

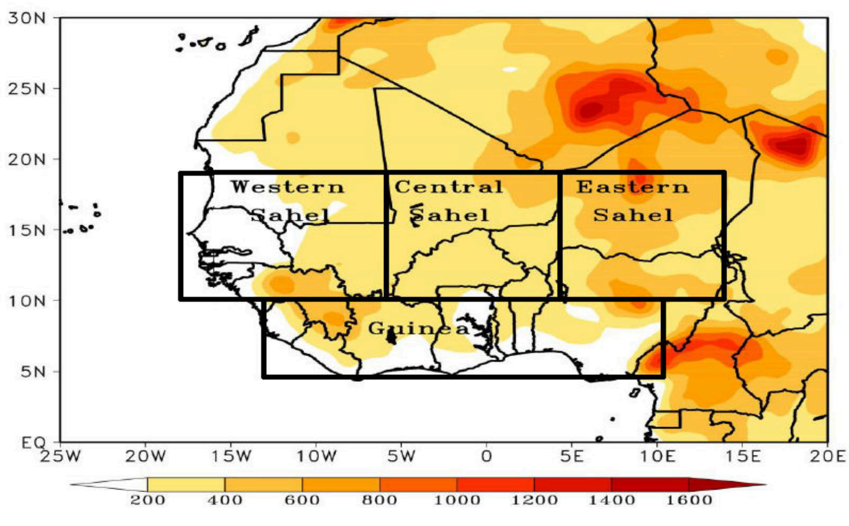

Fig. 1. Topography of the study domain (West Africa) and the considered sub-domains (Western Sahel, Central Sahel, Eastern Sahel, and the Guinea Zone)

Table 1. Definition of climate indices [36]

Indices	Indices abbreviate	Unit
Number of days with daily cumulative precipitation greater than 1 mm (number of wet days: R > 1 mm)	R1mm	Days
Simple daily intensity index (precipitation intensity due to the wet days only)	SDII	mm/day
Number of days with daily precipitation greater than or equal to 10 mm (Frequency of intense rainfall events: R >= 10 mm)	R10mm	Days
The maximum of 1-day precipitation accumulations	RX1DAY	mm
Contribution of very wet days; total precipitation>95th percentile (The value below which 95% of the data are found)	R95P	mm/day
Maximum length of the consecutive wet days with daily rainfall greater than 1 mm (maximum wet spell length)	CWD	Days
Maximum length of the consecutive dry days with daily rainfall below 1 mm (maximum dry spell length)	CDD	Days

3 RESULTS

3.1 MODELS VALIDATION

The RegCM4 simulations analyzed in this study are extensively validated in [27]. In this section, we assessed the performance of the RegCM4 and WRF models in simulating rainfall over West Africa. For this purpose, we compared the summer rainfall (May to September, MJJAS) simulated by the two models with the CHIRPS observations data. represents the mean summer rainfall (May to September from 1981 to 2010) for the CHIRPS climatology and the two regional climate models and their difference with CHIRPS data. CHIRPS observations exhibit a zonal distribution with precipitation decreasing from the South to the North and maxima located over orographic regions: Fouta Jallon Mountains (FJM), Jos Plateau (JP), and Cameroon Highlands (CH) (Figure 2a). The two models well simulated the zonal structure of rainfall as well as the maxima (Figure 2b, c). The RegCM4 model simulates a dry (wet) bias over the Sahel (Guinea Coast) while the WRF model simulates an opposite bias (Figure 2d, e). Moreover, the low biases simulated by the two regional climate models show their good ability to well simulate summer rainfall over West Africa. To go further in the study of the performance of the models over West Africa, we computed and presented in the mean bias and the pattern correlation coefficient (PCC) of the monthly rainfall for the RegCM4 and WRF models with respect to CHIRPS observations data in the four sub-domains shown in The mean bias characterizes the sign of errors (overestimation or underestimation) committed by the two models, while the PCC allows characterizing the linear interdependence of two climate parameters. The RegCM4 model simulates dry bias (annual mean value) over the Sahel (Western, Central, and Eastern) while the WRF model simulates a wet bias (annual mean value) over these three zones (Table 2). The two regional climate models overestimate rainfall over the Guinea zone with 10.56 mm/month for the RegCM4 model and 25.76 mm/month for the WRF model (Table 2). displayed the annual cycle of rainfall over the Sahel (western, central, and eastern) and the Guinea zone from the CHIRPS climatology and the two regional climate models. CHIRPS climatology shows a rainfall peak in August over the Sahel (western, central, and eastern) and a rainy season that starts in April (Figure 3a, b, c). Over the Guinea Coast (Figure 3d); the CHIRPS datasets exhibit a bimodal regime of rainfall with two peaks (two rainy seasons) around June and September. The two regional climate models well simulate the annual cycle of rainfall over the Sahel zones and the Guinea zone with sometimes an overestimation or underestimation. The next step is to assess the performance of the two regional climate models in simulating extreme rainfall over West Africa.

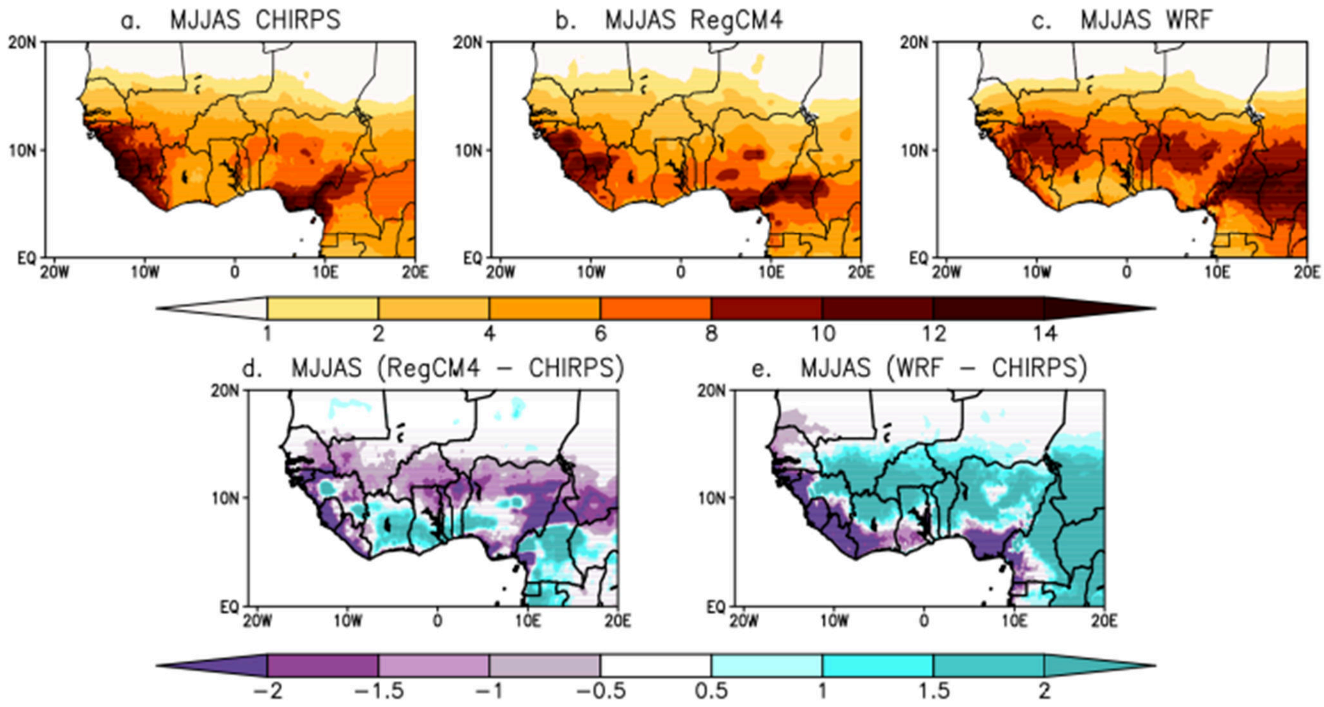

Fig. 2. Mean summer (May to September) rainfall (mm/day) averaged from 1981 to 2010 over West Africa: (a) for CHIRPS climatology, (b) for RegCM4 model, (c) for WRF model, (d) RegCM4 – CHIRPS and (e) WRF – CHIRPS

Table 2. Mean bias (MB) expressed in mm/month and pattern correlation coefficient (PCC) of the monthly rainfall for the RegCM4 and WRF models with respect to CHIRPS observations data

Periods	Western Sahel		Central Sahel		Eastern Sahel		Guinea Zone		West Africa	
	RegCM	WRF	RegCM	WRF	RegCM	WRF	RegCM	WRF	RegCM	WRF
	MB	MB	MB	MB	MB	MB	MB	MB	PCC	PCC
January	0.69	0.44	0.57	0.81	0.02	0.19	5.03	42.49	0.77	0.76
February	0.80	1.86	1.30	4.81	0.33	0.79	3.33	44.50	0.83	0.86
March	1.63	6.01	9.21	16.26	6.21	10.21	30.50	69.69	0.78	0.81
April	3.35	5.85	36.17	40.25	31.78	40.40	70.42	78.20	0.91	0.85
May	2.89	3.79	21.61	41.97	25.78	47.87	58.68	67.94	0.91	0.87
June	-2.52	3.21	3.83	54.94	9.18	59.18	19.82	31.8838	0.89	0.81
July	-13.17	26.25	-32.96	67.69	-33.45	45.10	-0.75	-13.49	0.87	0.76
August	-43.36	-2.82	-58.91	34.02	-49.90	13.96	-7.61	-41.27	0.86	0.75
September	-29.55	22.76	-32.37	-6.26	-31.67	-17.84	-33.23	-43.41	0.87	0.80
October	-18.34	3.05	-2.22	2.68	-4.46	1.32	-35.04	-18.04	0.88	0.86
November	0.99	3.80	1.63	2.56	0.55	0.90	9.24	42.97	0.90	0.89
December	0.24	0.86	0.13	0.34	0.08	0.24	6.39	47.70	0.83	0.82
Annual	-8.03	6.26	-4.33	21.67	-3.80	16.86	10.56	25.76	0.93	0.88

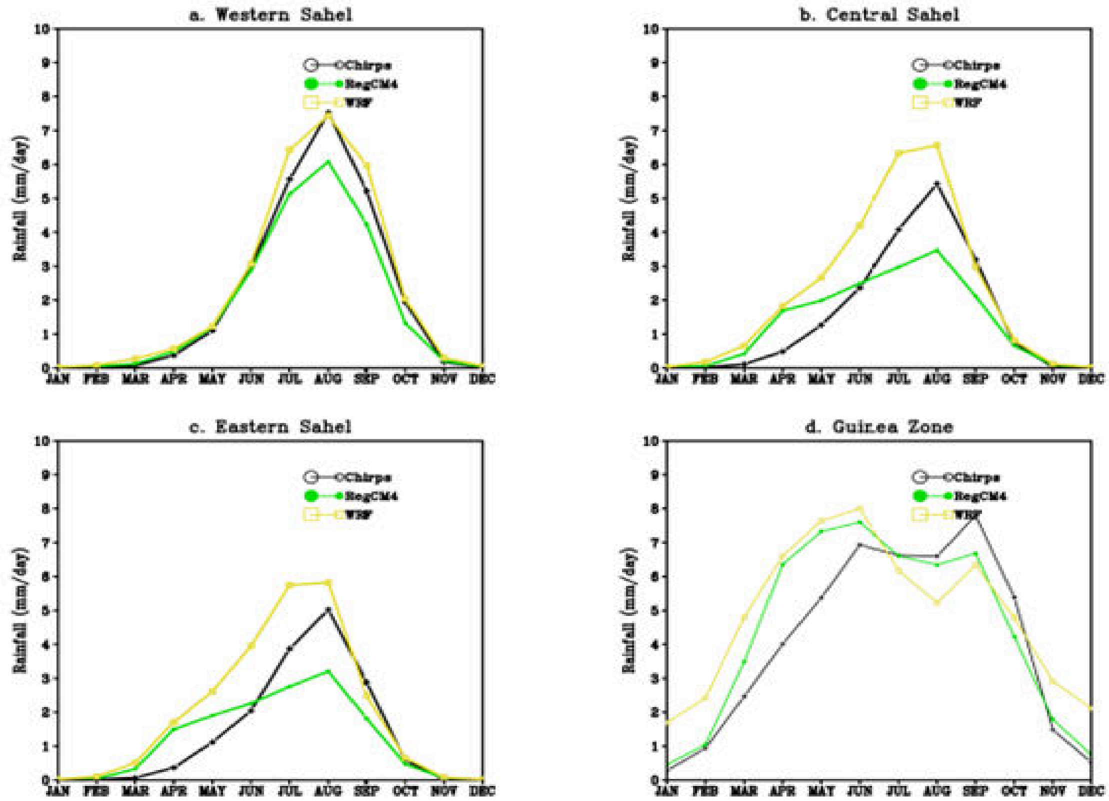

Fig. 3. Annual cycle of monthly precipitation from CHIRPS climatology, RegCM4 model, and WRF model-averaged from 1981 to 2010 over: (a) the western Sahel, (b) the central Sahel, (c) the eastern Sahel, and (d) the Guinea zone

3.2 Spatial Variability Of Extreme Rainfall

Climate change and changes in extreme precipitation events will affect West African populations with an increase in their vulnerability [39]. shows the number of rainy days and intense rainfall days averaged during the summer period (May-June-July-August-September) from 1981 to 2010 for the CHIRPS climatology and the two regional climate models. The CHIRPS observations (Figure 4a) show a maximum number of rainy days along the Intertropical Convergence Zone (ITCZ) especially over the mountainous areas (Fouta Jallon highlands, Jos Plateau, and Cameroun Mountains). The two regional climate models well simulated the spatial distribution of the number of rainfall events with the position of the maxima and the minima (Figure 4b, c). The number of rainfall events decreases from the southern to the northern Sahel for CHIRPS data and both regional climate models. CHIRPS data (Figure 4d) show strong values of the intense rainfall events over the orographic regions (Fouta Jallon highlands, Jos Plateau and Cameroun Mountains). Similar distributions are simulated by the two regional climate models (Figure 4e, f) with the position of the maxima. The spatial distribution of the simple daily intensity index (SDII) which is calculated as the mean intensity of the number of rainy days is displayed in for the CHIRPS data and the two regional climate models. CHIRPS data (Figure 5a) show higher rainfall intensities over the orographic areas (especially over the Guinea highlands) and the minima over the Sahel region. The two regional climate models well simulated the spatial distribution of the rainfall intensities during wet days with the position of the maxima and the minima (Figure 5b, c). In the next step, we diagnose the spatial variability of extreme rainfall events that play an important role in agriculture and flood over West African countries.

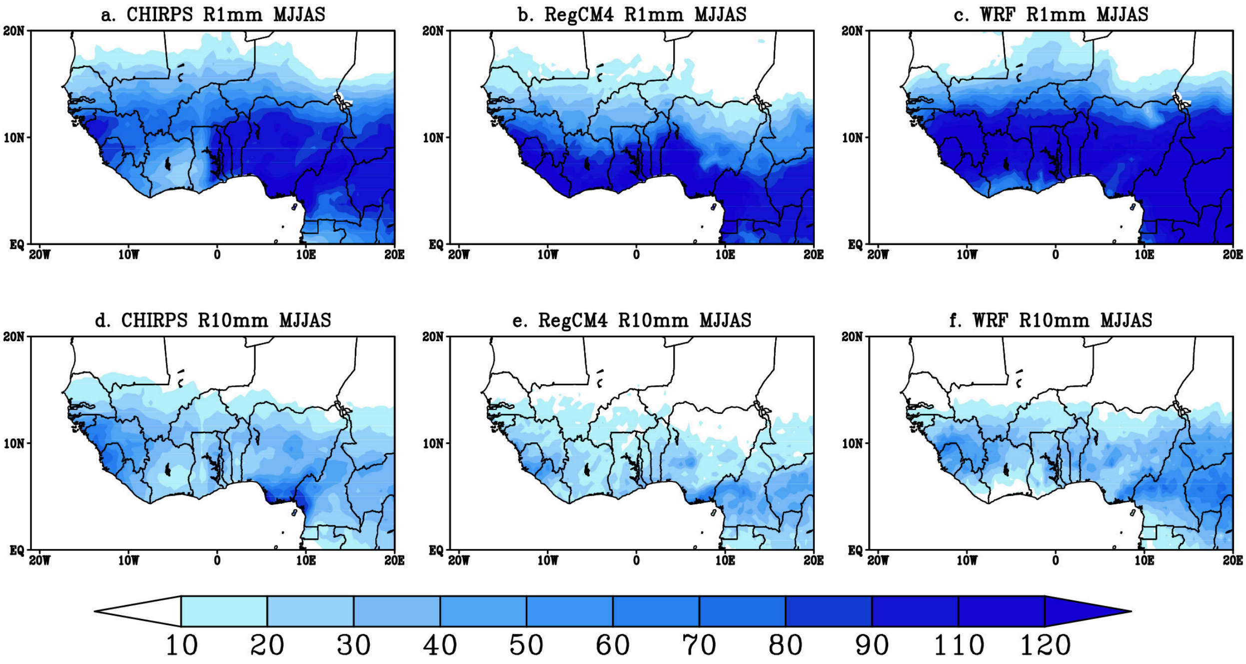

Fig. 4. Number of rainy days and intense rainy days during the summer period (MJJAS) averaged from 1981 to 2010 over West Africa: (a, d) for CHIRPS climatology, (b, e) for RegCM4 model, and (c, f) for WRF model

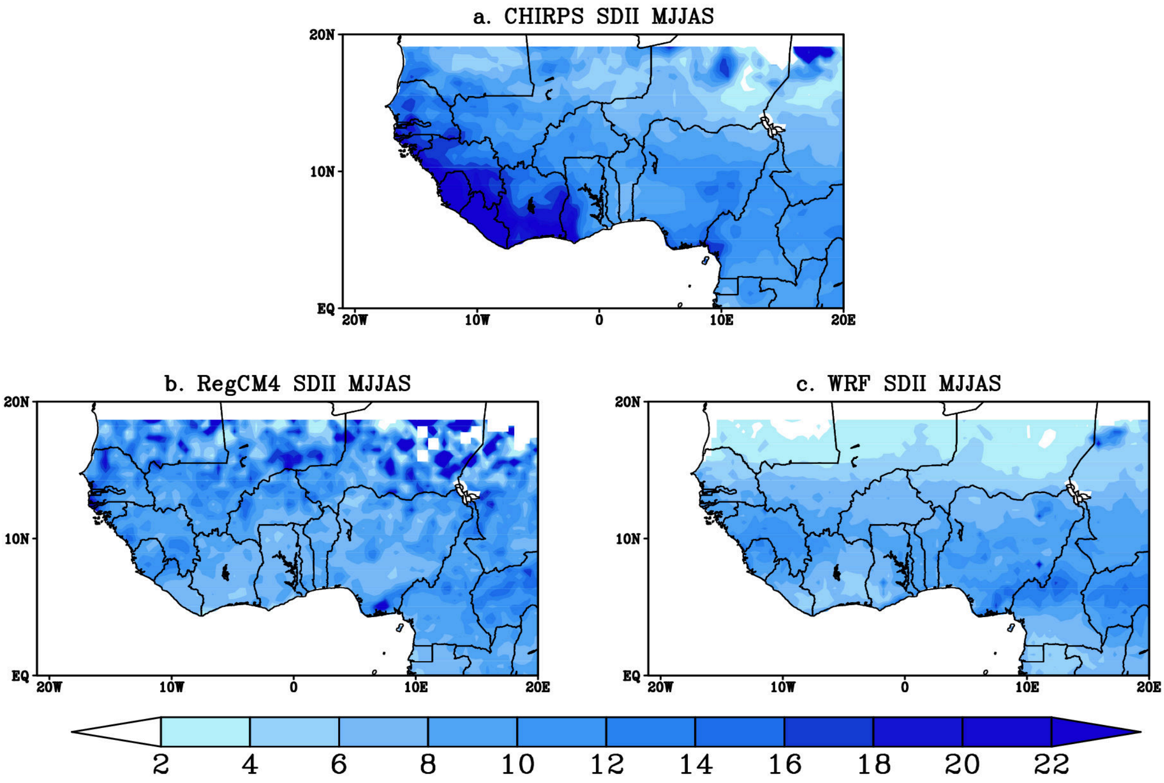

Fig. 5. Mean summer simple daily intensity index (mm/day) averaged from 1981 to 2010 over West Africa: (a) for CHIRPS climatology, (b) for RegCM4 model, and (c) for WRF model

The maximum cumulative precipitation RX1DAY (1-day precipitation accumulations) and the mean 95th percentile which characterize the very wet days are calculated and displayed in These two parameters are a major concern for local populations over West Africa where agriculture production depends mainly on rainfall amount. CHIRPS climatology (Figure 6a) shows a strong 1-day precipitation accumulation over a latitudinal band between 3°N and 12°N especially over orographic regions (Fouta Jallon Mountains; Jos Plateau and Cameroon highlands). The two regional climate models well simulate the 1-day precipitation accumulations with the position of the maxima and the minima (Figure 6b, c). The CHIRPS datasets (Figure 6d) exhibit a zonal distribution of the mean 95th percentile similar to the mean summer rainfall. The maxima of this index are located south of 15°N (along the Intertropical Convergence Zone) and over the Guinea zone, Jos Plateau, and Cameroon highlands. The RegcM4 and WRF models well simulate this zonal distribution and the maxima and minima (Figure 6e, f).

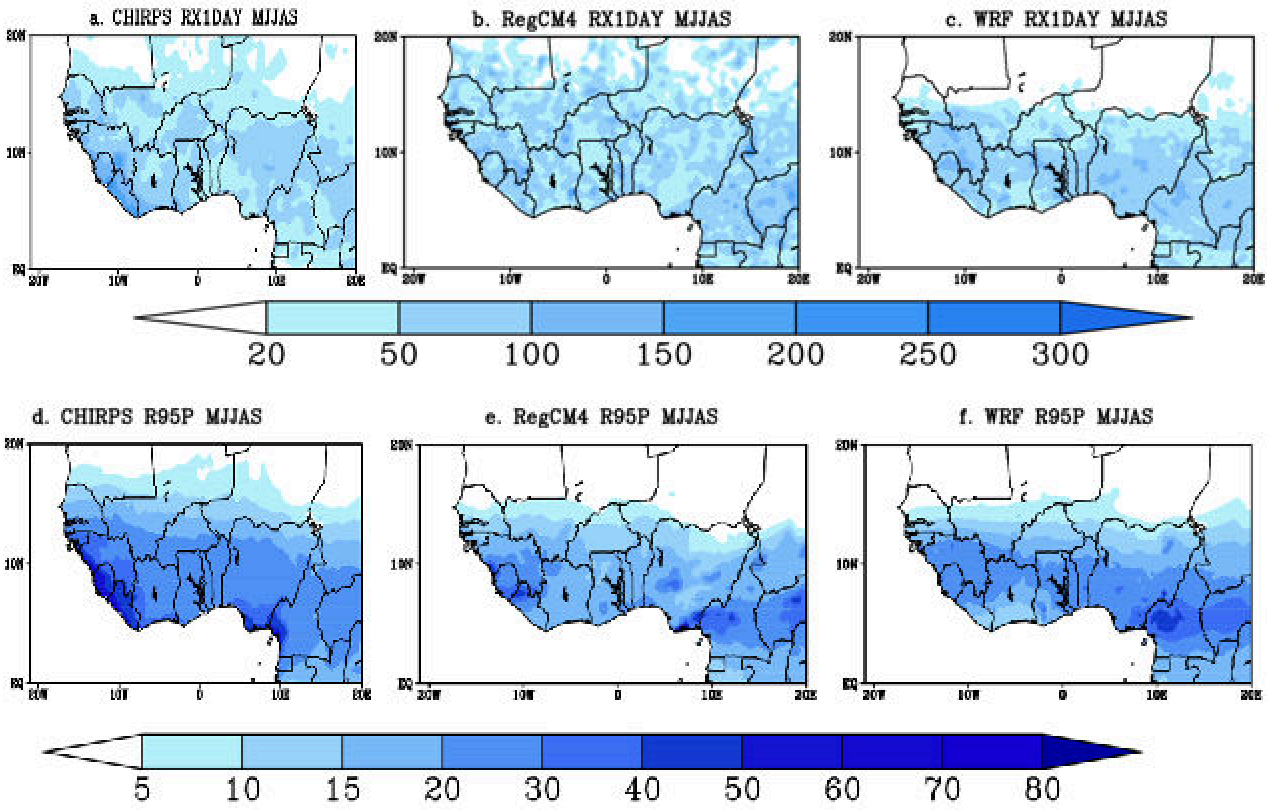

Fig. 6. The maximum 1-day precipitation accumulations (RX1DAY: mm) and the mean MJJAS 95th percentile of daily rainfall events (mm/day) averaged from 1981 to 2010 over West Africa: (a, d) for CHIRPS climatology, (b, e) for RegCM4 model and (c, f) for WRF model

The maximum duration of the consecutive wet days (CWD) and the consecutive dry days (CDD) known to be crucial for agriculture over West Africa are displayed in for the CHIRPS data and the two regional climate models. CHIRPS datasets (Figure 7a) show a spatial distribution of the consecutive wet days similar to the number of rainy days (Figure 7a). The two regional climate models well simulate this distribution with strong values over the orographic regions (Fouta Jallon highlands; Jos Plateau and Cameroon highlands) and the Guinean coast (Figure 7b, c). When considering the CDD, CHIRPS datasets exhibit stronger values of this parameter (Figure 7d) north of 17.5°N (northern Sahel). The shorter consecutive dry days are observed over the area of the maximum precipitation (over the southern Sahel and the orographic regions) (Figure 7d). Similar distributions of the CDD are simulated by the two regional climate models (Figure 7e, f). The consecutive wet (dry) days are favorable (unfavorable) for agriculture over West Africa.

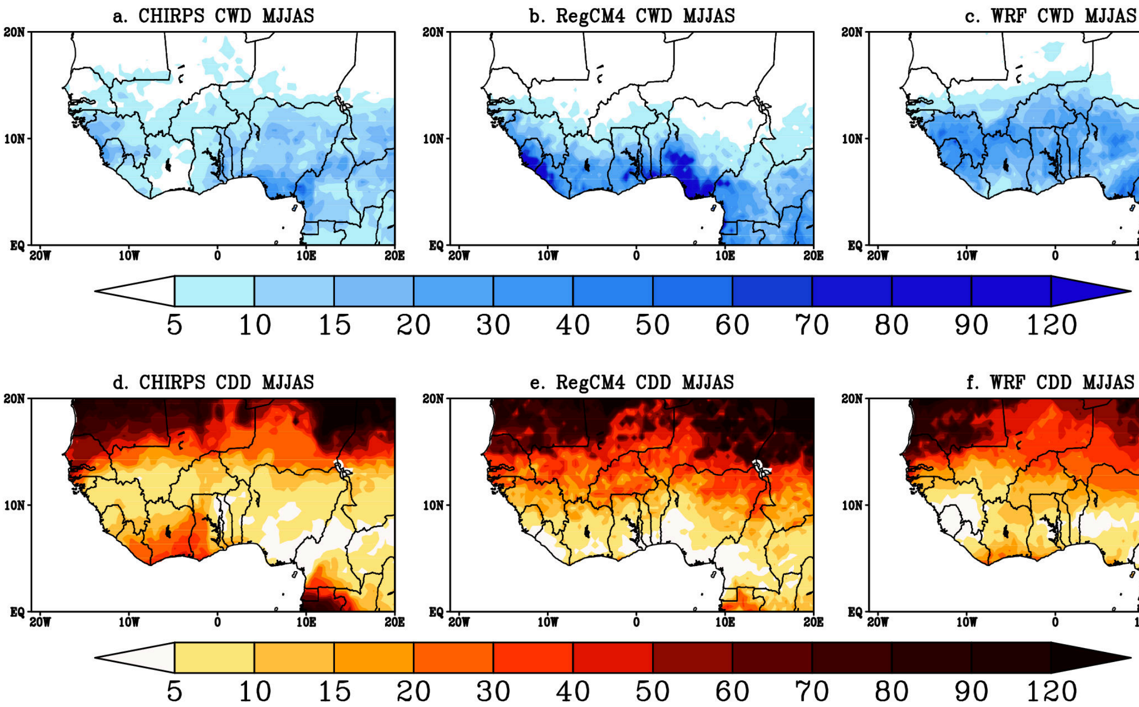

Fig. 7. Maximum length of the consecutive wet days (CWD) and the consecutive dry days (CDD) during the summer period (MJJAS) averaged from 1981 to 2010 over West Africa: (a, d) for CHIRPS climatology, (b, e) for RegCM4 model and (c, f) for WRF model

3.3 Spatial Variability Of Some Atmospheric Parameters

To better explain the spatial pattern of model biases and extreme rainfall events, the summer (MJJAS) mean relative humidity (%) integrated into the lower layers (between 1000 and 850 hPa) for the ERA-Interim reanalysis and the two regional climate models is shown in The ERA-Interim reanalysis shows a dipolar structure of this parameter with maxima located in the southern Sahel, over the Guinean coast and the ocean, and the minima in the northern Sahel (Figure 8a). The two regional climate models well simulate the spatial distribution of the relative humidity and the position of the maxima and the minima (Figure 8b, c). The RegCM4 model underestimates this parameter over the Guinea Coast compared to the ERA-Interim reanalysis (Figure 8b). This could explain partly the dry biases (negative value) simulated by this model over the Sahel (Figure 2d). Moreover, the wet biases (positive value) simulated by the WRF model over the Sahel (Figure 2e) could be due partly to the strong relative humidity simulated by this model over the Guinea Coast compared to the ERA-Interim reanalysis and the RegCM4 model (Figure 8a, c). This strong relative humidity is consistent with the rainfall increase over the same region and the Sahel. The wind dynamics are also analyzed to better interpret the synoptic variability associated with precipitation events over the study period. shows the May to September (MJJAS) average wind module at the monsoon level (925 hPa), zonal wind at the African Easterly Jet level (700 hPa), and zonal wind at the Tropical Easterly Jet level (200 hPa) over West Africa. The Era-Interim reanalysis shows a strong monsoon flow over the Guinea Coast and the southern Sahel (Figure 9a). The two regional climate models well simulate the spatial distribution of the monsoon flow at the lower level but underestimate its intensity. Moreover, the RegCM4 model underestimates it more than the WRF model. At 700 hPa, the WRF model simulates a strong African Easterly Jet (AEJ) between 10°N and 15°N compared to the Era-Interim reanalysis and the RegCM4 model (Figure 9d, e, f). At 200 hPa, the Era-Interim reanalysis and the WRF model show the Tropical Easterly Jet (TEJ) core around 5°N while the RegCM4 model simulates it around 7°N (Figure 9g, h, i). There are moderate differences in the atmospheric circulation shown by the Era-Interim reanalysis and simulated by the two regional climate models. These moderate differences in the wind dynamic combined with that of the moisture content of the atmosphere may be partly responsible for the mean rainfall and extreme rainfall changes when considering the two regional climate models.

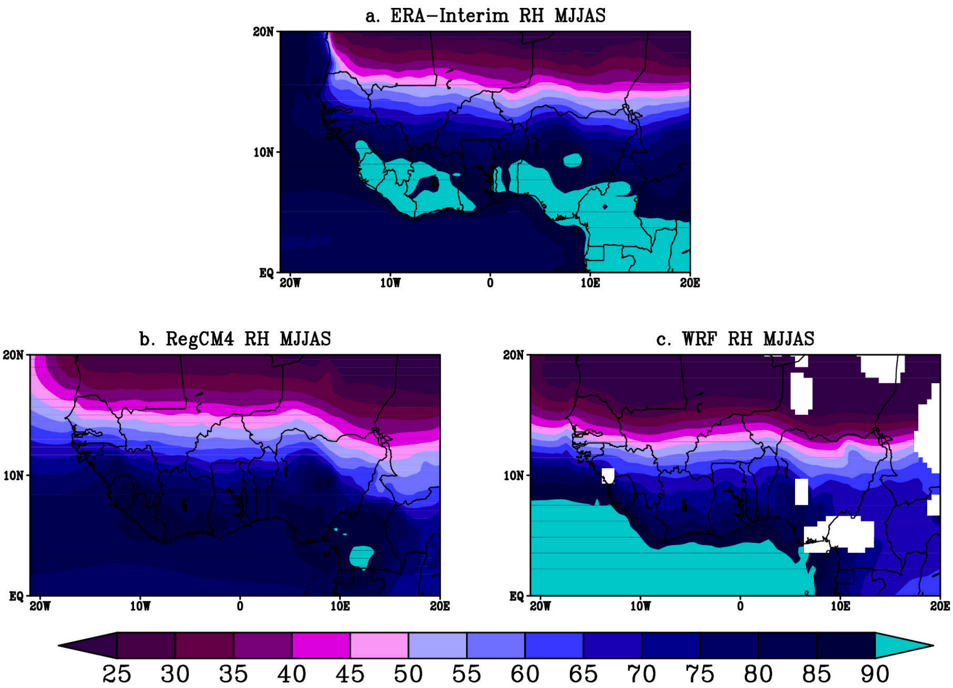

Fig. 8. Relative humidity (%) averaged from 1981 to 2010 over West Africa: (a) for Era-Interim reanalysis, (b) RegCM4 model, and (c) WRF model

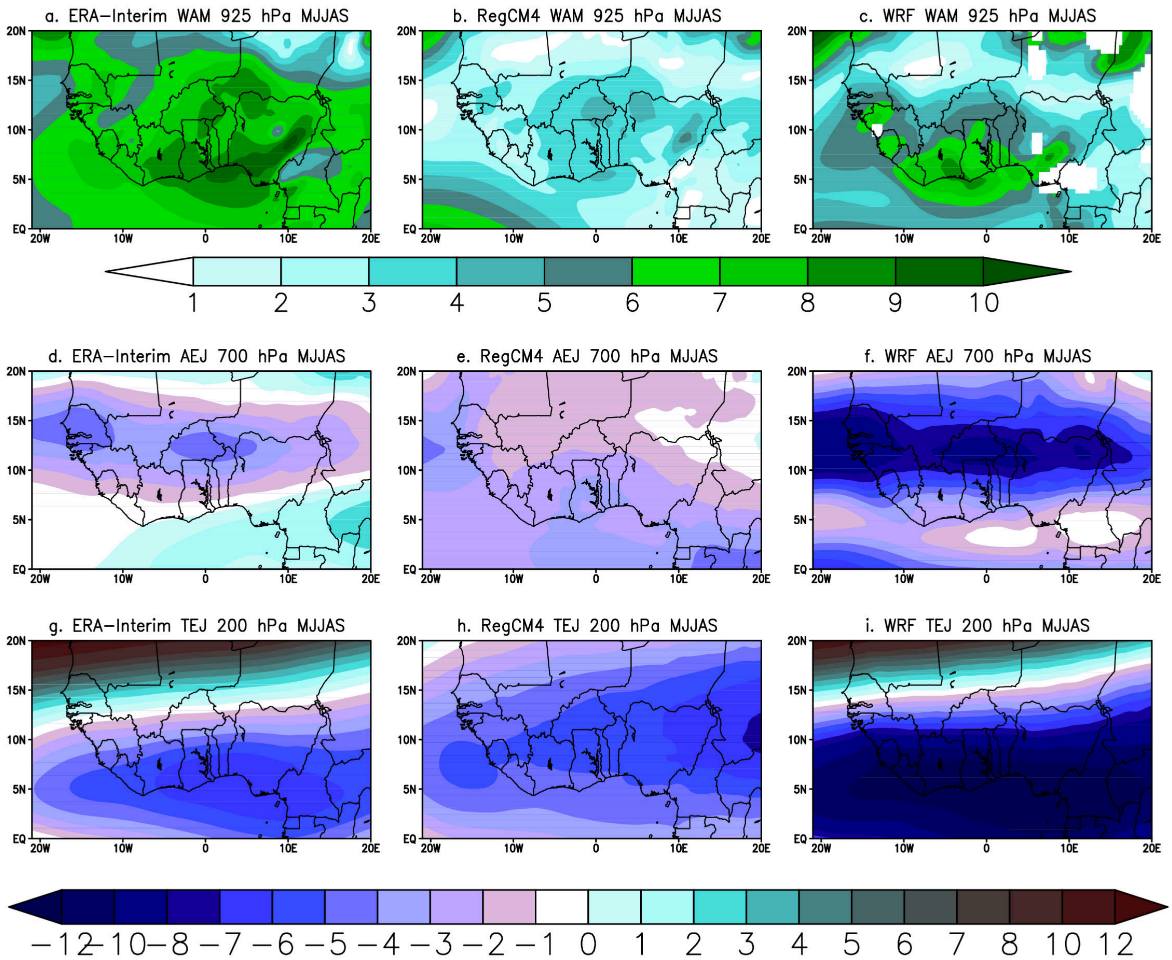

Fig. 9. (a, b, c) Wind module at the low-levels (925 hPa), (d, e, f) averaged MJJAS zonal wind at the mid-levels (700 hPa), (g, h, i) averaged MJJAS zonal wind at the upper-levels (200 hPa) from 1981 to 2010 over West Africa: for Era-Interim reanalysis (left), RegCM4 model (center) and WRF model (right)

4 CONCLUSION

This work presents the results on the spatial variability of seven (7) rainfall extreme indices recommended by the World Meteorological Organization (WMO) using CHIRPS datasets and two regional climate models (RegCM4.5 and WRF3.5) during the period 1981-2010. CHIRPS climatology shows a strong 1-day precipitation accumulation over the latitudinal band between 3°N and 12°N especially over orographic regions (Fouta Jallon Mountains; Jos Plateau and Cameroon highlands). The two regional climate models well simulate the 1-day precipitation accumulations with the position of the maxima and the minima. The number of rainfall events decreases from the southern to the northern Sahel for CHIRPS data and both regional climate models. CHIRPS data show the highest rainfall intensities over the Guinea highlands and the minima over the Sahel region. The two regional climate models well simulated the spatial distribution of the rainfall intensities during wet days with the position of the maxima and the minima. Strong values of the intense rainfall events are obtained over the Fouta Jallon highlands, the Jos Plateau, and the Cameroun Mountains for CHIRPS data and both regional climate models. The CHIRPS datasets exhibit a zonal distribution of the mean 95th percentile of daily rainfall similar to the mean summer rainfall. The maxima of the mean 95th percentile are located south of 15°N (along the Intertropical Convergence Zone) and over the Guinea zone, Jos Plateau, and Cameroon highlands. The RegcM4 and WRF models well simulate this zonal distribution and the maxima and minima. CHIRPS datasets show a spatial distribution of the consecutive wet days similar to the number of rainy days. The two regional climate models well simulate this distribution with strong values over the orographic regions and the Guinean coast. When considering the consecutive dry days (CDD), CHIRPS datasets exhibit strong values of this parameter north of 17.5°N (northern Sahel). The shorter consecutive dry days are observed over the area of the maximum precipitation (over the southern Sahel and the orographic regions). Similar distributions of the CDD are simulated by the two regional climate models. The increase of strong rainfall events may induce dramatic consequences such as flooding. In terms of model biases, this study shows substantial differences between the two regional climate models used in this study suggesting the necessity to perform models intercomparison over the present-day before any choice for future projections. There are moderate differences in the atmospheric circulation shown by the Era-Interim reanalysis and simulated by the two regional climate models. These moderate differences in the wind dynamic combined with that of the moisture content of the atmosphere may be partly responsible for the mean rainfall and extreme rainfall changes when considering the two regional climate models.

Despite the results obtained in this study, additional works are needed to better explain the spatial distribution of the extreme precipitation events over West Africa for the present day but also for the future using climate change scenarios because extreme rainfall and temperature events remain a major concern for West African countries which are known to have a low adaptation capacity.

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